Superconducting Detectors for Microwave Astronomy

Scientific Achievement

We are advancing a new approach to the long wavelength detection problem based on superconducting films and structures. Superconductors are already used for various applications such as mixers and receivers, modulators, quasi-optical filters, resonators, and other devices. In this project a method of controlling the coordinate sensitivity in a high temperature superconducting bolometer was realized experimentally using lithographically defined YBCO films. This novel detection technology, by which the coordinate sensitivity of a microfabricated superconducting stripe is controlled, is an alternative solution to imaging with Focal Plane Arrays. Thus a superconducting film patterned into a meander structure is equivalent to a two-dimensional detector array. In additional to the straightforward detector fabrication sequence, a clear advantage of this approach is the simplicity of the read-out process: only two electrical terminals are used to construct a full image. The proposed approach can be extended for imaging over a wide spectral range, including infrared, terrahertz and microwave radiation. For applications requiring the highest sensitivities we are controlling of the effective critical transition temperature by exploiting proximity effects in low temperature composite normal metal / superconductor bilayers to achieve low transition temperatures (low noise). The growth conditions for fabrication of Mo / Au bilayers with an optimal transition temperature of 0.5K for high sensitivity microwave bolometer have been established experimentally. Current efforts are to combine the materials synthesis and microfabrication processes for further studies of noise and electronic transport in thermally insulated single-pixel superconducting detectors.

Significance

Through this partnership project between Argonne National Laboratory and University of Chicago, we aim to develop *state-of-art* superconducting Transition Edge Sensor technology for astrophysics applications. These sensors are required for the next generation of Cosmic Microwave Background (CMB) polarization measurements, the goal of which is to probe the beginnings of the universe by detecting or setting an upper limit on the energy scale of Cosmic Inflation. Bolometric detector technologies have already reached background-limited performance, so only by increasing the number of detectors and using a high throughput telescope such as the South Pole Telescope will it be possible to achieve the necessary increase in sensitivity to detect and characterize the faint CMB polarization signals. This requires at least a 1000-fold increase in sensitivity. The development of planar-coupled focal plane arrays with 1000 pixels or more offers a sensitivity advantage of more than a factor of 10 over current systems. Furthermore, planar antennas can feed detectors of multiple frequency bands and two-polarizations offering additional increases in information-gathering capabilities.

Performers:

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